Computer-Aided Discovery of Earth Surface Deformation Phenomena

Completed Technology Project (2015 - 2017)

Project Introduction

Key Objectives: Earth scientists are struggling to extract new insights from a sea of large data sets originating from multiple instruments. The goal of this proposal is to provide enhanced assistance to enable the most beneficial division between human and machine efforts. We propose the creation of enhanced environments for computer-aided discovery that support humans in the search process of making new discoveries related to earth surface deformation phenomena. Methods & Techniques: Earth surface deformation measurements currently rely on two key techniques. Over 4000 continuously operating GPS sites collect global information to study motions of the Earth's surface with accuracies as low as 0.5 mm per day. Interferometric Synthetic Aperture Radar (InSAR) detects deformations based on imaging and has sensitivity of a few millimeter differential motions over swath widths of up to 100 km. After an earthquake both GPS and InSAR are analyzed in detail to model the co-seismic offsets, seismic wave propagation (GPS only) and post-seismic processes. Our understanding of deformation processes can be furthered by including additional data characterizing for example volcanic inflation, episodic tremor slips or characterizing biases in a better way, such as snow on antennas, antenna failures, or atmospheric delays. To identify and eliminate such anomalies, scientists need to gain insight by cross-comparison of multiple data sets acquired through different techniques and instrumental principles. The data portfolio available to Earth Scientists already includes GPS sensor time series, InSAR, MODIS imagery, land temperature, GRACE gravity field changes, and upcoming missions like NASA NISAR mission will increase the temporal density of InSAR images by orders of magnitude. Scientists therefore need better automation support and more sophisticated tools. We propose an approach for computer-aided discovery based on software infrastructure providing key features to facilitate the discovery search: (1) A software environment engaging scientists to programmatically express hypothesized scenarios, constraints, and model variants (e.g. parameters, choice of algorithms, workflow alternatives), so as to automatically explore with machine learning the combinatorial search space of possible model applications in parallel on multiple data sets and identify the ones with better explanatory power. (2) A cloud-based infrastructure realizing a high-performance parallel model evaluation capability for data sets that reside in NASA's data centers. Various search modes will be provided, e.g., including one where the system can use scientist feedback from model evaluations to parameterize the search in new runs and direct the system to identify more analogous features and reduce false positives. Workflows will be stored in a workflow warehouse in the cloud so other scientists can easily rerun them on new data sets. We will demonstrate our approach with three specific case studies. (1) Volcanics at Yellowstone; (2) Groundwater phenomena in the Central Valley; (3) Atmospheric phenomena and effects of lee waves on position determination. All demonstrations will use a fusion of data sets consisting of GPS, InSAR, and other data that is archived at UNAVCO and NASA Earth Exchange. This data contains known phenomena as well as other

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Center / Facility:

NASA Headquarters (HQ)

Responsible Program:

Advanced Information Systems Technology

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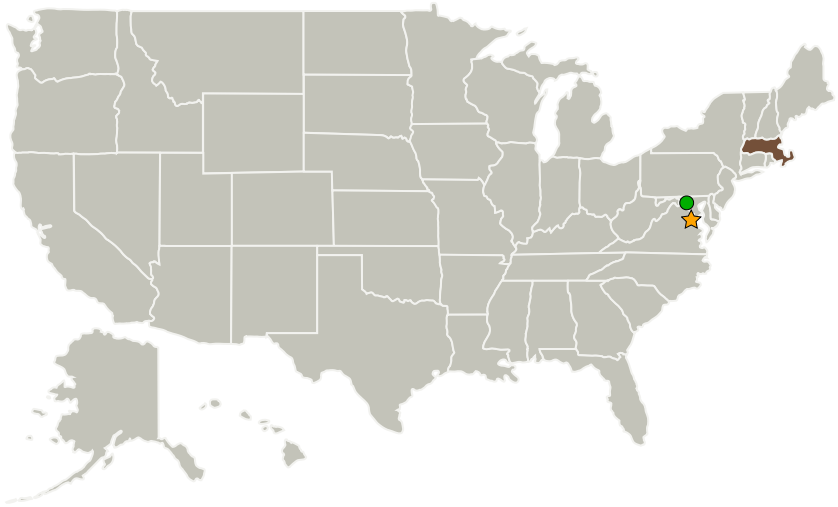
potentially unknown phenomena, so it can be leveraged for controlled computational experiments to quantify the effectiveness of our techniques. Significance: Our proposal will advance NASA's capability for modeling, assessment, and computing of Earth Science data (2.1.2 Computational Technologies; 2.2.1 Innovation Breakthroughs for Modeling, Analysis, and Prediction) and improve technical means to assess, mitigate, and forecast natural hazards. Computer-aided discovery will enhance the productivity and ability of scientists to process big data from a variety of sources and generate new insight.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★NASA Headquarters(HQ)	Lead Organization	NASA Center	Washington, District of Columbia
●Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland

Primary U.S. Work Locations
Massachusetts

Project Management

Program Director:

Pamela S Millar

Program Manager:

Jacqueline J Le Moigne

Principal Investigator:

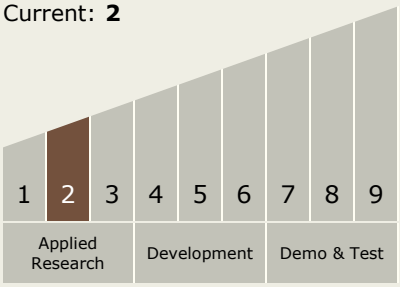
Victor C Pankratius

Co-Investigators:

Michael P Corcoran
Thomas A Herring

Technology Maturity (TRL)

Start: **2**
Current: **2**



Technology Areas

Primary:

- TX11 Software, Modeling, Simulation, and Information Processing
  - TX11.4 Information Processing
    - TX11.4.2 Intelligent Data Understanding

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Target Destination

Earth